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FOR THE

COMMON SCHOOLS.

BY

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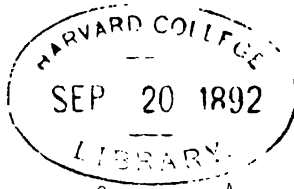
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Zoology.

There is hardly a more useful auxiliary to the science work which relates to animal life than an aquarium. If it be possible to have a strong metal-framed one connected with a steady water supply, it will save much trouble, but one may be managed very well without such conveniences. If no connection with pipes can be made, it is better to have several of medium size than to have one large one. Fish globes, eight or ten inches in diameter, are inexpensive and will be found very useful.

A small aquarium may be made thus: use an inch board one foot wide and one foot long for the bottom, and two boards of the same thickness and width, ten inches high for the ends. Three-eighths of an inch from the edge on either side, with a saw, make a groove one-quarter of an inch deep, and wide enough to receive loosely double strength glass. Groove the end boards and fasten them to the bottom with screws so that the grooves will exactly match. Partially fill the grooves with soft putty, or better, aquarium cement, and press into each side a pane of glass. By making the bottom board eleven and one-half inches long, an ordinary ten by twelve window pane will be the proper size. When the glass is pressed to the bottom of the groove, draw the two ends in at the top until the glass is held firmly and then fasten them in place by narrow strips of wood, one on each side of the tank, placed on top of the glass and screwed to the end pieces. These strips also protect the hands from injury while working with the specimens in the aquarium. Before filling with water, the inner surface of the bottom and ends should be well rubbed with oil or paraffine and the grooves inside the glass well packed with putty. The bottom should be covered with an inch or two of sand and coarse gravel.

Two or three of this size will enable one to preserve safely a large variety of specimens, and sufficient in amount to keep up an interesting study of animal life throughout the winter. Indeed, if the supply falls short, they may be restocked at any time of the year. By dragging the bottom or edges of a pond or ditch, which is covered with leaves

and grass, with a hand rake, using a net, one may usually in the midst of winter gather an abundance of minnows, tadpoles, snails, crawfish, frogs, water beetles, etc.

I. GENERAL OBSERVATIONS.

1. Are any birds to be found at this time?
2. Are they winter residents?
3. Have they been here all the year or have they come from some other locality?
4. What is their food? How do they find protection from storms?
5. Where do they stay at night?
6. Is their winter garb different from that of summer?
7. Are they mated, in flocks, or solitary?
8. Look for insects under stones, boards, leaves, etc. Have they lined their nests in any way as a protection against the cold?
9. If they are not active keep them for a short time in a warm room.
10. Do they show signs of life?
11. In the same way, search for earth worms.
12. What substitute have these animals for migration?
13. What do they do for food?
14. Animals lying through the winter in a dormant state are said to hibernate.
15. Put a common mud-turtle in a box of wet sand and cover loosely with a lid. Keep the sand wet.
16. Note the time when he disappears; he will probably not be seen again for months.
17. How do you think the chances for life of a hibernating animal compare with one that is migratory?
18. Why does the animal hibernate when kept in a warm room in winter time?

II. ANIMAL COVERINGS AND WARMTH.

1. What changes do we make in our clothing as winter approaches? In material? Color? Thickness? Texture?
2. How do the brute animals make similar preparation?
3. Is the winter plumage of birds the same as that of summer?
4. How do birds preen their feathers? Why?
5. How are the coverings of water fowl especially adapted to their mode of life?
6. Study the arrangement of the feathers on a bird; a pigeon or

sparrow may be readily obtained for the purpose. Are the feathers distributed evenly over the body?

7. Is there any obvious advantage in the manner in which the feathers are distributed?

8. Mention the uses you can see for feathers?

9. What animal can you name that is covered with fur? Name one covered with hair? What difference is there between fur and hair? Examine a dog and a cat.

10. Can you suggest any reason why one animal is provided with fur and another with hair?

11. Which is the better protection against injury? Which is the warmer covering?

12. Where are fur-bearing animals found? Where are those with a hairy covering found? Compare wool with both hair and fur?

13. Read something of the history and habits of the fur and wool bearing animals.

14. Study the scales of a fish and snake; what is their chief use in each case?

15. Do the coverings of fishes and snakes change in any way with the seasons?

16. If possible, secure a snake skin that has been shed and examine it closely; how does the snake get out of it? Are the scales shed?

17. Is the right side out? Note the transparent covering that was over the eye.

18. How does the covering of the turtle differ from that of both the snake and the fish?

19. Do insects have skins? How does the outside of an insect's body differ from most other animals studied?

20. What peculiarity in the covering of a crawfish? What is its most important use?

21. Can you see how it is possible for the animals which have such hard coverings to grow?

22. How do the different modes of life of the various animals observed correspond to their coverings?

III. THE SKIN OF THE HUMAN BODY.

1. Compare the skin on the back of the hand with that on the palm in color, thickness, sensitiveness and markings.

2. Why is the greater thickness on the palm?

3. On what other parts of the body is the skin similar to this? Why?

4. What is the effect of manual labor on the skin in the palm?

5. Is there any difference in the causes which operate on the palm and on the sole of the foot?

6. What causes the creases in the palm?

7. Note the short hairs covering the back of the hand; examine with small magnifying glass. At the root of each hair is a small oil gland which pours out upon the surface a minute quantity of oil. Notice the softness and flexibility of the skin.

8. When is it that the skin on the hands becomes harsh and chapped?

9. How is oil affected by cold weather? How must it affect the flow from the glands in the hands?

10. How do the hands feel after having had them in soap-suds? What must be the effect of the soap on the oil?

11. Why should the skin be wiped dry after washing?

12. What is the best way to prevent the hands from becoming chapped?

13. What would you suggest as the natural remedy?

The outer layer of the skin which sometimes may be rubbed up as white scales, and which forms the clear skin in a blister, is the cuticle or scarf skin. As it dies and is worn off it is replaced by the true skin underneath. When dry, it cracks and exposes the sensitive layer lying under it.

A small cake of pure mutton tallow rubbed over the hands at night is a simple and effective remedy. It should not be smeared on in great quantity. Nature never oils the skin in that way, and we should imitate her in this respect.

14. What is perspiration? Is it pure water?

15. What causes tend to increase perspiration? To diminish it?

16. Passing outward through the skin and opening at its surface, are very many minute tubes that convey the perspiration from the sweat glands; these are situated in the deeper layers of the skin. The openings of these glands may be seen through a magnifying glass in rows in the palm.

The sweat glands in health are continually throwing off from the body waste matters which are carried to them by the blood.

17. How must the heat of the body be affected by the evaporation of perspiration from its surface?

18. Do you become warmer or cooler when you perspire freely? Since the skin thus assists in maintaining a proper heat in the body, it is a *heat regulator*.

19. Rub a little oil briskly on the hand; what becomes of it? Has it evaporated?

20. Why is it that liniments may be applied to the skin for ailments that lie deeper, as in case of a sprain? The skin is an organ of *absorption*.

21. On what part of the body is the skin most useful in giving us the sense of touch?

22. The sensitiveness of the skin in different parts may be tested by using a pair of dividers with sharp points thus: close the eyes and allow some one to touch the skin in various places, now with the single point then with the double point. Find when you can distinctly distinguish the two points when they are closest together.

23. Try in this way the palm, back of hand, cheek, tongue, lips, back of neck, arm, ear, etc.

24. How many important uses have we found for the skin?

25. Examine one of the finger nails. Note the opaque area near the base called the lunula, and also how the skin is attached around the inner end.

26. Does the skin grow fast to the edge of the nail?

27. Why does the skin sometimes break and peel backward from the base of the nail?

28. To prevent this, loosen the skin by running around the edge the dull point of a knife:

29. In what way are the nails most useful? What happens if they are allowed to grow too long? If trimmed too closely? How does the care of the nail affect the shape of the finger-tips?

30. How does biting the finger nails spoil them?

31. Why is a knife better than scissors for trimming them? The nail is made of thin layers, and scissors, especially dull ones, tend to separate them.

32. Of what use to us is the hair on the head?

33. Can you give a good reason for brushing and combing it?

34. Note the white powdery flakes that may be sometimes brushed from the head. Where do they come from?

35. Compare these with the cuticle which may be rubbed from the back of the hand.

36. What gives the softness and flexibility to the hair?
37. What is the effect of using soap and water upon it? Why is it so?
38. Why is it necessary to wash the hair? If the scalp is healthy no oil is needed, and if it is not, oil will do but little good. Treat the scalp much the same as you do the skin on other parts of the body.
39. How many distinct uses of the skin may be named?
40. How may it best be cared for as an organ of protection? Contrast the effects of indoor and outdoor occupations upon it. What are the effects upon the skin of bodily exercise in fresh air?
41. How may its usefulness as an organ of touch be increased?
42. In what occupations is a refined sense of touch necessary? Of what use is it to a physician? How do the blind utilize it?
43. Test yourself as to this sense; can you distinguish by touch a one-cent piece from a dime? A five-cent piece from a two-cent piece? sugar from salt? Salt from sand? Can you distinguish flannel from heavy cotton cloth? Printed from unprinted paper?
44. How is the usefulness of the skin promoted by bathing?
45. How does the work of the skin necessitate frequent change of clothing?

BOOKS FOR REFERENCE.—As a text-book, Martin's *Human Body*. Humboldt's *Library*, No. 4, *Man's Place in Nature*. See also the Nos. previously recommended in work for September and October.

Botany.

The activity of plant life out-doors has ceased, and but little can be done with the study this month except to examine the dormant condition of those plants which live through the winter, and to note the provisions made for the succeeding season by those that do not. The nice adaptation of the plants to their changed environments is the chief point to be observed.

1. Have the plants completed their preparation for winter?
2. Can you find any that continue to grow until the leaves fall?
3. Do the first frosts kill any of the newly grown twigs? Examine as many different kinds of trees as possible.
4. What changes have the new twigs undergone since summer?
5. Can you find any plants that have been entirely killed?
6. How will such plants be reproduced next season?
7. How does the number of seeds produced by plants that are killed each year by frost compare with the number produced by plants that live from year to year? Which class of plants seems to have the better mode of scattering its seeds?
8. Are there any seeds to be found? Can you find any which by some means have been planted? Remove a small pan-full of earth to the warm school room and see if any self-planted seeds will grow.
9. Can you find any plants which came from the seed last spring that have been entirely killed by the frost? Such plants are called *annuals*.
10. Plants which live over from year to year are called *perennials*.

REFERENCES.—See October.

Physics.

In the experiments to be performed, it is the intention to have the pupils prepare the apparatus, under the direction of the teacher, and do all the work.

The teacher must see that the directions are closely followed that the conditions may be as nearly perfect as possible. Ideal results are not to be expected, but for what is lost in this respect, compensation may often be found in a close study of the disturbing elements which rendered them inaccurate. Interpretation of the results of all the experiments must be insisted upon and concise statements, together with descriptions of the apparatus, in many cases accompanied with drawings, should be required.

In some instances, teachers fail because they do not allow the pupils sufficient time in which to prepare their apparatus. With the mind fixed upon an expected result, they too often force the experiment regardless of proper precautions which should have been taken. In describing an experiment the pupil should always be required to state what precautions are necessary to be observed. There is as much for the pupil, often, in the careful preparation and manipulation of the apparatus as there is in the outcome of the experiment itself.

In the following work with a little care on the part of the teacher, a good deal may be accomplished in the cultivation of a "temperature sense" in the pupil. While it does not rank high among the senses in usefulness, and in most persons it is but poorly developed, it should not by any means be neglected. With but little practice the pupils will be able to judge with considerable accuracy, of the different degrees of temperature of water between the freezing point and that of 130° or 140° Fahrenheit.

I. TEMPERATURE.

1. Provide a small vessel of water and a thermometer. The water should have a temperature of 50° or 60° . Hold the fingers in this till familiar with the sensation. Place the thermometer in the vessel and note the temperature.

2. Apply heat until twenty degrees hotter, and again let the pupils test with the fingers and then measure with the thermometer. In this way, test with the hand and measure with the thermometer until the fingers can be held in it but a few seconds only.

3. Begin again with the temperature first taken and by adding snow or ice reduce to the freezing point, testing with the fingers and reading the thermometer as before.

4. Repeat these experiments changing the temperature ten degrees each time instead of twenty.

5. After holding the fingers a short time in ice water, dip them in water having the temperature at which you began ; does it feel warmer or cooler than before ? The pupil should test with his fingers and express his judgment as to the temperature in each case before using the thermometer.

6. Why is testing the temperature in this way with the fingers likely to be untrustworthy ?

7. Note the temperature of the school room ; it should be about 68° . Compare with that of a hall way. Daily practice should be given in judging the temperature of the room.

II. EXPANSION.

1. Fasten one end of a small iron rod or wire, a foot long, tightly in a small support of some kind. Against the free end arrange an index finger in such a way that it will move over a dial. The index should be several inches long and the wire should rest against it near the pivot.

2. Apply heat to the rod throughout its length ; note the movement of the index. What does its movement indicate ?

3. Withdraw the heat ; does the rod still rest against the index ?

4. Substitute a brass rod for the one of iron and note the movement of the index.

5. Cut or punch a hole in a piece of tin large enough to just allow a rod to pass through it smoothly. Heat the rod and try passing it through the hole. What does this indicate ? Cool the rod and try again.

7. Can you see any reason why a blacksmith should heat the tire of a wheel before putting it on ?

8. Why is there a space between the ends of the rails in a railroad ?

9. Why heat the bolts and rivets used in putting together the parts of iron bridges and boilers ?

10. Allow each pupil to fill a small bottle level full of water which has been colored with a little indigo or ink. Pass a glass tube a few inches long and of small bore, say one-eighth of an inch, just through the cork; it should not project below the under surface of the cork. Press the cork tightly into the bottle and the water will rise in the tube; see that no bubble of air rests underneath the cork and that none are clinging to the inside of the bottle. The water should stand in the tube so as to be visible above the cork, and the point to which it rises should be marked. This is easily done by slipping down over the tube a small piece of paper.

11. Place this in a shallow pan containing sand, and heat gradually over the alcohol lamp.

12. Can you notice any movement of the water in the tube? Why is the tube used?

13. What is the effect of heat upon the water?

14. Make a drawing of the apparatus used and explain why each successive step is taken in its arrangement.

15. Using the same apparatus, place the bottle in a vessel containing snow or ice mingled with salt. Watch sharply the column of water in the tube.

16. Compare its movements with those when the bottle was heated.

17. In order to test the temperature, one bottle with a wide mouth should be prepared with the tube and also a thermometer through the cork. At what temperature does the water begin to rise in the tube? Does it expand beyond its original volume?

18. From these two experiments can you think of what changes and movements the water in a pond must undergo in being frozen?

19. Why does ice form at the top and not at the bottom of a pond or stream?

20. What would likely be the result if the ice should begin to form at the bottom?

21. Prepare the bottles again as above, but fill them only about half full of water and push the tube through the cork until it reaches nearly to the bottom.

22. Clasp the upper part of the bottle in the hands and watch the tube.

23. Compare carefully the conditions of this experiment with those in the last. What essential difference between them?

24. Heat the bottle as before, over a lamp; account for the result observed.

25. If possible, procure a bladder or a small rubber bag partially filled with air; warm it gently and account for the result.

III. LIQUEFACTION.

1. Take two wide-mouthed bottles as nearly alike as possible and fill one with ice and the other with the same weight of water; place both in a pan of boiling water over a lamp or gas jet.

2. Note the temperature of each at intervals until the ice is all melted.

3. Have the two vessels received the same amount of heat? Note the conditions carefully under which each is placed.

4. What difference in temperature when the ice is melted?

5. Had the temperature of the bottle with the ice in it risen at all at the moment it was melted? What change did the heat bring about in the bottle?

6. After the ice has melted, does the thermometer indicate any change?

7. Remove to a sand bath and raise the temperature of the water until it boils. A thin glass beaker or vessel of tin should be used for the purpose.

8. What is the temperature at which it boils? Hold the thermometer in the steam over the liquid.

9. Increase the heat by means of more burners; does the temperature rise?

10. What has been accomplished by the heat in these experiments with the water and ice?

11. When heat is applied to a body or fluid does it always show itself as temperature? When not shown as temperature how is it expressed?

BOOKS FOR REFERENCE.—Humboldt Library, No. 120, The Modern Theory of Heat, and The Sun as a Storehouse of Energy.

Chemistry.

In this and other science work it will sometimes be necessary to have a means of getting a strong heat without smoke. If gas is at hand it is best to procure a Bunsen burner and attach it to a jet with a rubber tube. An alcohol lamp however will make a good substitute. To make one of these, take a small bottle and perforate the cork, making a round opening three-eighths of an inch in diameter. With a small piece of tin make a tube an inch or two long that will tightly fit the hole through the cork, allowing it to project a short distance above. The seam of the tube need not be soldered. Roll a small flat lamp wick tightly and pass it through the tube. A large sized thimble may be used as a cap for extinguishing the flame and to prevent waste of alcohol when not lighted. The cork should rest loosely in the bottle when in use.

1. Take a small stick of wood and cut it into fine pieces; set fire to another similar one and let it be consumed. Watch closely the changes taking place.
2. How has the wood been changed in the first instance? Are there any changes in amount?
3. Has there been any change whatever in the substance of the wood?
4. What was the first change noticed in the burning wood? Note the charring.
5. Does anything remain after burning has ceased? What is it?
6. Does it in any way resemble the wood?
7. Is there in what remains either as great bulk or weight as there was in the wood?
8. What has become of the part that has disappeared?
9. Allow the smoke to strike a piece of porcelain or glass; what collects on the surface?
10. Does the soot in any way resemble the wood?
11. Was it a part of the wood?

12. Hold the flame of an alcohol lamp under and near the soot on the plate ; what becomes of it ? Is it totally consumed ?

13. What is the greatest difference, in result, of the above operation upon wood ?

14. In the first instance there was a *physical change* ; in the second a *chemical change*.

15. Try lowering the lighted stick into a wide mouthed bottle ; try again with a bottle or jar of larger size ; compare the burning under such conditions with those in the first instance.

16. What conditions seem to be necessary for the burning of the wood ?

17. Is the air in the bottle changed when the stick is burned in it ?

18. Pour into a clean bottle half an inch of lime-water and shake it ; does it change ?

19. Now burn a match in the bottle and shake again ; is the lime water changed ?

20. Does this recall the results of any experiment of a previous month ?

21. Drop a piece of marble into a small bottle of strong vinegar or into water mixed with hydrochloric acid ; how does the action differ from what takes place when it is put into water ? (See Chemistry for October.)

22. Use a piece of limestone in place of the marble ; describe closely what occurs.

23. What do the bubbles contain ? Lower a lighted match into the bottle.

24. By means of a bent tube through the cork, draw some of the gas formed out into a small amount of lime-water ; do the results with the lime-water and match recall any previous experiments ? This is a test for carbon dioxide gas.

25. What tests proved it to be different from air ? In what respects is it like air ?

26. Place in a Florence flask or pint bottle a handful of pieces of marble and cover them with water and add hydrochloric acid till gas comes off freely. Through a bent glass tube in the cork convey the gas to the bottom of another wide-mouthed bottle or a beaker.

27. After a few minutes, with a movement as of pouring, invert the beaker over a burning taper or match ? How do you account for the result ?

28. Why is it possible to collect this gas in an open beaker as we did? Why is it possible to pour it like water?
29. When the bubbling ceases pour off the liquid and dry the solid that remains; does it differ from what was used originally?
30. Will acid act upon it again as it did at first?
31. Try the vinegar with chalk or limestone or marble that has been mixed with water.
32. Have the substances in the above experiments undergone physical or chemical change?
33. Take a small amount of sulphur and mix thoroughly with about the same quantity of iron filings; can you distinguish the two substances in the mixture?
34. Can you separate the two substances? Blow upon the heap.
35. Pass a magnet back and forth near the mixture; what is the result?
36. Make another similar mixture of sulphur and filings in a cup; warm gradually over the burner.
37. Watch closely and describe the changes that take place.
38. After the action ceases, examine the substance formed and compare with the original materials.
39. Can you distinguish the sulphur? How does it differ from the filings? The new substance thus formed is called iron sulphide. Instead of writing the word iron in full, the symbol Fe is generally used, and instead of the word sulphur, the symbol S is written. Iron sulphide has for its symbol, Fe S. In the first instance the iron and sulphur formed merely a mixture; in the second, a combination. What is the difference?
40. Which experiment with the filings and sulphur more closely resembles that with the acid and marble?
41. In what important particular are they different?
42. In how many of the experiments performed, could you distinguish new substances that were formed?
43. What were the tests used which proved their presence?
44. How does the new substance which was formed in the bubbles of vinegar differ from the Fe S in the last experiment?

BOOKS FOR REFERENCE.—Remsen's Introduction to the Study of Chemistry.

Meteorology.

1. How does the mean temperature for the first week compare with that of the first week in October? What causes the difference?
2. Is the direction of the prevailing wind the same as it was for October? Is it a cold or a warm wind?
3. How can you account for its direction?
4. What wind is accompanied by a clear sky? How does this wind affect the temperature?
5. What wind has accompanied the rains? Are the rains more or less frequent than they were in the preceding months?
6. How does the amount of rainfall compare with that of the preceding months?
7. What is the most common form of cloud observed?
8. How have they changed in character? Are they higher or lower than they were in September?
9. Which is the more common this month, frost or dew?
10. What is the character of a night preceding a frost?
11. Does the frost form upon all objects out-doors?
12. How does a windy night affect the formation of frost? A cloudy night?
13. Examine some frost crystals under a lens.
14. Are they uniform in shape and size? Are frost crystals frozen drops of dew?
15. What difference is there between the conditions for forming dew and those for forming frost? In what respect are they the same?
16. Has the barometer in any way indicated the change noted in the weather?
17. What was the mean height of the barometer on the clear days?
18. What was its mean height on the rainy or stormy days?
19. In what month has the barometer shown the greatest range of movement? In which the least?
20. In what month has there been the greatest fluctuation in the weather? In what month the least?

21. Is there any uniformity in the temperature which accompanies a falling barometer? Is it the same or different with a rising barometer?

STUDY OF SIGNAL SERVICE MAPS.

22. Do the isotherms vary more or less this month from their general direction than they did last month?

23. Where is the variation greatest? What cause can you assign?

24. In what part of the country has there been the heaviest rainfall?

25. Where has there been the most snow?

26. Where is the region of lowest temperature?

27. Do the mountains have the same effect upon the isotherms that they did in September?

28. Do the coast lines exert the same influence upon the isotherms as last month?

29. What was the lowest isotherm that passed through this locality during the month?

30. What was the lowest latitude of that isotherm in September? In October?

31. What inference may be derived from its varying position?

Astronomy.

The facts that have been noted from time to time as to the variation in the length of day and night, the change of season, the changing shadow, the different position of the rising and setting sun on the horizon, should all be used in giving the pupils a clearer idea of the earth and the sun in their relative positions, and also broader conceptions of these bodies themselves. To accomplish the latter end, the pupils should be trained to think of the earth and the sun without the use of the globe for illustration. Make the same use of the symbol in this case as in all others; use it only as an aid to the conception of the object, but do not let it entirely take the place of the object, inasmuch as then the pupil's conception must be of the symbol only.

1. Compare the length of day and night with that of preceding months.

2. Is the rate of variation each day the same during the month? How does it differ from that of October and September?

3. In what direction is the noon-mark changing? Why?

4. Is it changing more or less rapidly than it did in the preceding months?

5. Are the facts observed thus far sufficient to prove the revolution of the earth around the sun?

6. What other supposition can you make that would account for the phenomena observed?

7. Use a globe if necessary to illustrate your meaning?

8. Has the diminishing day had anything to do with the changing season?

9. Show to what other cause the change in season is due.

10. What time elapses between two new moons?

11. Show what the position of the moon must be with respect to the earth and sun when it is new. Why is it crescent-shaped?

12. In what direction do the horns point? Why do they point in this direction? Does the direction vary? Why?

13. Does the moon always follow the same path across the sky?

14. Where does the new moon always appear first? Why?

15. Where is it when between old and new?

16. The constellations to be observed are the same as those for October.

BOOKS FOR REFERENCE.—Astronomy Science Primer, by Lockyer. Newcomb's Astronomy, Briefer Course. See previous months.

Geography.

I. CLIMATE OF NORTH AMERICA.

By a judicious reference to the Signal Service Maps, and to maps of the continent upon which are marked the isotherms, a detailed study of the climate of North America may proceed from month to month. It must not be expected that the pupils will generalize sufficiently to be able to see all the laws underlying the distribution of heat and moisture, yet such use of the maps will assist them to collect in a practical way a large number of the facts upon which the laws are based and which open the way for a clear understanding of the laws further along. The data gathered from the study of physical maps should be used to supplement and extend the knowledge and experience they have gained from their own observation recorded in their Meteorological Record.

1. What regions of the United States show the greatest contrasts as to rainfall during the month?
2. Note the latitude of the two regions; also the elevation, the winds which traverse them, and their nearness to the sea.
3. Can you tell what conditions have most affected the rainfall?
4. Which condition has the most to do with the temperature of the two regions?
5. What difference is noted in the temperature of the two places?
6. Contrast the character of the prevailing winds upon the Pacific slope with those upon the Atlantic; how do the two regions differ in temperature in the same latitude?
7. Is the difference in temperature dependent upon the winds? Note the direction from which they come in each case.
8. Compare the rainfall of the interior between the two great mountain systems with that on the coasts. What is the direction of the prevailing wind in the interior?
9. Compare the rainfall in the northern and southern regions of the interior; upon what does the difference depend?
10. How can you account for the difference in temperature of the northern and southern divisions of the interior?

11. What contrasts in temperature and rainfall are noted between the mountainous parts and the lowlands?

12. What contrasts, that you know of, between the people of different regions are due to difference in climate?

13. Are any differences that may exist between the people on the Pacific coast and the Atlantic coast due to difference in climate? Are the differences as well marked as they are between the North and the South? Why?

14. Contrast the people of the far north with those of the extreme south, as to character, habits, occupation, etc. How does the climate affect them?

15. How does difference of climate affect the productions in our latitude?

16. Where are there the greatest contrasts in the productions in the same latitude? Are these due to climatic differences?

17. Compare the rainfall for the month of the region just east of the Rocky Mountains with the region just west of the Appalachian Mountains; how do you account for the difference?

18. Where do the winds that sweep the two regions come from?

II. DRAINAGE OF SOUTH AMERICA.

1. Note, by the examination of a good map of South America, the ocean which receives the greatest part of the drainage waters; compare in this respect with North America.

2. From the flow of the rivers, how can you tell the location of the continental slopes? Bound the slopes.

3. Where is the great continental water parting?

4. How does it compare in relative position with the great continental water parting of North America? How does it compare in direction?

5. What resemblance in the two continents as to their great slopes? Compare the two Pacific slopes. The Atlantic slopes.

6. Do the rivers in the north of each continent indicate any similarity in the slopes in these regions?

7. What minor water partings are indicated by the rivers of the eastern slope?

8. How does the position of the minor water partings differ from those of North America? How do they compare in direction?

9. Compare the slopes of the interior with those of North America.

10. In what directions does the interior slope?
11. What resemblance and difference can be discovered in the great river systems of the two continents?
12. What differences as to their minor river systems?
13. What part of the continent must receive the greatest rainfall?
14. Compare the northern and the southern parts as to rainfall, basing the comparison upon the size of the rivers.
15. Compare the regions as to rainfall with corresponding parts of North America; what difference noted? Why?
16. What inference based upon the great rivers, can you make respecting the fertility of different regions of the eastern slope? What inference in this respect about the western slope?
17. Where is the greatest river basin? What are its boundaries? The second, and third in size?
18. How does the general slope of these basins as wholes differ?
19. Compare the Brazilian Highland with the Appalachian.
20. In what latitude are the greatest rivers? In what latitude are the smallest rivers? Compare with North America.

Geology.

PEBBLES.

Have each pupil take the entire collection of pebbles gathered during the preceding months and assort them with respect to their different characteristics, such as shape, color, material, etc., and by a careful consideration learn something of their history. This work should be preceded by as much actual field work as possible. No teacher ought to hesitate to begin such field work, simply because of a lack of experience. It is the want of actual contact with things that renders so much teaching unsatisfactory to the teacher and obscure to the pupils. Visit some stream and spend a few hours studying the pebbles that line its banks. No matter how insignificant the brook may be, it will hardly fail to afford abundant illustration of the force of water in pebble-making. Fortunate indeed is the teacher who can also visit, with his classes, the shore of a lake or the sea, and there study the same force at work under different conditions. The wind, here plays a part equally important with the water, and the two together, through the ceaseless rolling waves, are as destructive as the swiftest current. The mobile water curling in graceful breakers and spreading itself out in thin layers on the beach, seems to possess but little of the force necessary to accomplish the results wrought out along every shore. But a cupful of water taken from one of these waves will show that it carries a multitude of sand grains that rasp each other and the shore continually. In the larger waves, great quantities of pebbles are constantly rolled in and out with the advancing and retreating waters, and the grinding, grating sound accompanying the alternate movements tells something of the great work that is going on. In times of tempest, the force is increased a thousand fold. With a thundering roar, the water laden with great boulders hurls itself in some places against the shore with a force sufficient to demolish the most substantial works of man; elsewhere, it rolls up immense heaps of sand, gravel, and stones, and leaves them perhaps hundreds of miles from the starting point of their journey.

If in addition to these illustrations it is possible to study and compare with them the action of the glaciers, the interest will be greatly increased.

The different forms of the glacial pebbles, the different manner in which they are deposited, the means by which they were carried, will all furnish rich material for careful thought and study. It is an excellent exercise for the reasoning powers to trace the history of a pebble from its present condition and surroundings, back through its various stages to its origin in some distant cliff in a remote age. How much of this history can be written, will depend upon the age and experience of the pupils; some will perhaps read its history only to water which rolled it and made it round; others will follow it to a particular lake or stream, and still others may see its foot-steps leading to some cliff. It little matters how far they go, or how far short of the end they may have to stop, if in accounting for them they learn to properly use and interpret the conditions under which the pebbles are found. It is not enough for a full conception that they follow merely the footsteps of the pebbles through space; the element of time is one of greatest importance, but it is a factor that can never be anything but vague in the minds of the most highly trained, and too much must not therefore be expected of young pupils. No effort should be spared, however, to broaden their ideas in this direction, inasmuch as a lack of this conception stands in the way of many people who cannot receive the modern theory of the earth's development.

Whether all or but one of the above illustrations of the results of water action are at the command of the teacher, let it once more be urged that the means at hand be used. It is the universal experience that not only do the facts so learned remain longer in the mind, but that such lessons often prove to be initiative of a line of observation and thought that lasts through life.

1. Where were the pebbles in your collection found?
2. Can you distinguish those that were found on the banks of a stream from those found on the shore of a lake?
3. What have you observed in the arrangement of pebbles on the river bank or lake shore? Is it exactly the same in both cases?
4. Have you found pebbles in any considerable quantity at a distance from water? Does the water reach the place in times of floods?
5. How can you account for this remoteness of pebbles from water? Are they like the rocks found in the quarries in the vicinity?

6. Can you tell whether they were deposited by running or still water?

7. Can you tell whether the water was shallow or deep?

8. Were they deposited on a shore or in the middle of a lake or stream?

9. Are there any other evidences of water action near by?

10. Can you form any estimate as to the length of time since they were deposited?

11. What things on the surface will assist in giving some idea of the time?

12. Are there any large trees in the vicinity? What is the depth of the vegetable mould? Is the sod well formed?

13. Which gives the best evidence of the length of time since the pebbles were deposited, the trees, the vegetable mould, or the sod?

14. What is the nature of the ground with which they are mingled, sandy, clayey or loamy?

15. How does the surface of a pebble differ from that of a freshly broken stone?

16. How does it differ from one that has been exposed to the air for a long time?

17. What makes this difference in surface?

18. Assort the pebbles with respect to shape; what is the most common form?

19. Why should they be rounded? Upon what does the shape appear to depend?

20. Is it the hardness of the material in the pebbles or its arrangement that does the more to determine their shape?

21. Assort and re-arrange the pebbles again with respect to the material composing them; compare as to color, hardness, etc.

22. Can you tell how it is that many different kinds are found together?

23. Does any one kind of material prevail to any great extent more than the others?

24. Is any of the rock composing the pebbles to be found in neighboring quarries?

25. Can you recall whether or not the ledges that may usually be seen projecting from a cliff or hillside are of the same kind of rock?

26. What evidence have you seen that such cliffs are wearing away?

27. A great variety of rock may be picked up by a stream travers-

ing many miles of country, but how is this variety possible with a lake?

28. How does the force which rounds off the pebbles in a stream differ from that in a lake or on the sea shore?

29. What part does the water really play in both cases?

30. Can you think of any conditions which affect the rate at which pebbles will be transported? Is this course a direct one to the mouth of the stream?

31. Under what conditions will they be deposited along the banks?

32. Under what circumstances will they be dropped in mid-stream? When will such be moved again?

33. Upon what conditions will those along the bank be allowed to remain?

34. Is it likely that pebbles left in sand on the building bank of a river will be again disturbed?

BOOKS FOR REFERENCE.—See September. Also Humboldt Library No. 38. Chapter I.

Mineralogy.

An interesting variation in the study of this subject this month will be found in a consideration of common mineral fuel.

The pupils should supply themselves, as far as possible, with specimens of bituminous, anthracite, cannel, and splint or block coals; also with examples of peat and coke. A good specimen of lignite is likewise needed to complete the list.

Compare the different specimens as to weight. Which is the heaviest? The lightest?

1. The weight of a solid or liquid compared with an equal bulk of water is called its specific gravity. To find the specific gravity of a solid, weigh it first carefully on an ordinary balance; then suspend it from one of the scale pans by means of a fine thread, and immerse it entirely in a small vessel of water, and obtain its weight submerged. The weight in air divided by the loss of weight in water is the specific gravity.

2. Which specimen has the greatest specific gravity? Which the least? Do you notice any correspondence between the specific gravity and the hardness?

3. What difference in lustre do you notice? Are they sufficiently well marked to enable one to distinguish the different kinds of coal? Some kinds show a play of different colors, and are known as peacock coal.

4. How do they differ in hardness? If you have different varieties of the same kind, i. e., specimens from different mines, can you notice differences in them?

5. Try with a lighted match to set fire to the different specimens, selecting sharp edges or corners for the purpose. Which one burns easiest? Which the most difficult?

6. Note the odor of the burning substance in each case; how does the peat differ from the rest?

7. What difference in the ways of burning in grates and stoves?

8. Compare the coke with the different coals. It is the carbon left

after burning the coal to rid it of other substances in its composition. It is used in smelting iron. (See Mineralogy for December.)

9. All the coals, and peat included, originate in the same way, but each different kind represents a different stage in formation. It is the result of immense beds of vegetable material becoming deeply covered in succeeding ages by the rock and earth now found above the coal seams. Peat is coal in its earliest stage of formation, and anthracite is coal in its latest and completed stage. It has been changed from the bituminous variety to that of its present character, by means of heat and pressure.

10. Examine a piece of the "lead" of a pencil; this substance is called graphite and is pure carbon. It is also known as plumbago.

11. If possible, get a piece of native graphite; note its lustre and peculiar feel.

12. What other uses has this mineral besides that in the manufacture of lead-pencils?

REFERENCE.—Read Applied Geology, by S. G. Williams.

Zoölogy.

I. GENERAL OBSERVATIONS.

1. Can any of the summer birds be found? If so, where do they stay?
2. Have you found any new-comers? Have they come from the north or south? What is their food? Do they sing? Are they building nests?
3. Is there any insect life abroad? Watch sharply on warm days and in sheltered places.
4. Hunt for earth-worms. How deep do they burrow in winter?
5. In what condition do the fish spend the winter? The craw-fish? Frogs?
6. Look for these under leaves and in mud along the sides and in the bottom of ponds.
7. Do tadpoles live over winter?

II. ANIMAL MOVEMENTS.

The following studies should be based upon what the pupils have been able to observe about their own movements, as well as those of the common domesticated animals. Ample opportunity should be given beforehand for the observations to be made, and the discussion should not be carried beyond the limits set by those observations. By this, it is not intended to circumscribe too closely any legitimate reasoning that the pupils may attempt, but merely to guard against the really vicious habit that some pupils have, in the beginning, of setting up some theory independent of any actual observation, and trying to defend it by vague speculations. That rapid progress may be made, pupils should be encouraged to be candid and to be ready to give up promptly any theory or supposition as soon as it can be shown to be inconsistent with the facts of observation.

1. Why is it necessary for most animals to move from place to place? Such animals are said to have the power of locomotion.
2. Do you know of any animals that cannot move about? How do they get their food? How are they protected from their enemies?

If possible, secure specimens of coral, sponges, and oysters in the shell. The points of attachment may easily be discovered and something of their modes of life may be learned.

3. How does the power of flight affect the life and habits of birds? Consider the advantages in food-getting, and in means of escape and attack, that are due to flight.

4. How has it affected their distribution? What barriers are difficult for birds to overcome?

5. Make a study of the way different animals walk; first examine those that walk on four legs, as the cat, dog, horse, cow, rabbit, squirrel, and any others that can be seen.

6. Contrast the cat and dog; what is the order in which they place their feet in taking a step?

7. Note the motions of the trunk of each as they step; what difference do you notice?

8. What gives the cat its stealthy tread? Its velvety paws contribute partly to it, but they are not the only cause. Notice as the cat steps how the body sinks slightly at the joints where the fore-limbs are hinged to the body and that the same is noticeable in the hind limbs at the knee joint, though somewhat less in amount. These movements, due to the great flexibility of the joints in the foot, and to the fact that when the fore-paw is put to the ground the leg is not vertically under the body but obliquely forward, give a spring to the step that is wanting in all other classes of quadrupeds.

9. Compare the movements of the cat with those of the dog; what reason can you think of for the difference in their gait?

10. What habit or need of these animals has done most to fix their gait?

11. Compare the movement of the horse and the cow; in what order do they place their feet in walking?

11. In what order are the horse's feet placed in trotting? What is the order in pacing or the rack? In galloping?

13. Does a cow trot? How does the movement of the hind legs differ from that of the horse?

14. Can you see wherein lies the greater capacity of the horse for speed?

15. How does the locomotion of the rabbit differ from that of the cat and dog? What is the order in which the rabbit moves his legs?

16. How do the rabbit and the cat differ in making a spring?

17. What is there in the life of the rabbit that makes him draw his hind legs under him in a crouching attitude?

18. In which are the hind quarters, compared with the fore quarters,

the more developed, the rabbit or the cat? Compare both of them with the dog.

19. How do the movements of the squirrel's legs differ from those of the rabbit's?

20. Which of the animals studied, does the squirrel resemble most in locomotion?

21. Compare the development of its different parts with that of the rabbit, dog, and cat; which does it most closely resemble?

22. In what kinds of places do these animals live in their wild state? How are their movements fitted for such places?

23. In animals that walk on two legs, to what uses is the other pair of limbs devoted?

24. How does the movement upon two limbs affect the position of the body? Why is the position of the bird less upright than that of man?

25. What are the advantages of the upright position for man?

26. Is there any advantage in turning the toes out in walking? What joint permits of this turning of the toes outward?

27. Which is the easier mode of walking, with the feet parallel, or diverging outward at the toes? Which is the natural and which the acquired way? Observe children learning to walk.

28. What difference in the bearing or carriage of persons is caused by the direction given the foot in walking? Take a few steps very slowly, and study the position of the body at each step.

29. In walking with the feet parallel, compare the transverse space between the tracks with the space when the toes diverge.

30. Which mode of walking contributes more to erectness of attitude? Why? Test by walking slowly. It will be noticed that in walking with the feet parallel, there is a slight rolling motion at the hips and that the body sways somewhat from side to side. The swaying is increased 'since the feet are usually placed a little wider apart transversely, in order to broaden the base. The body is bent slightly forward when taking steps thus.

When the toes are turned outward, the distance transversely between the feet is less, and the swaying motion at the hips is partially lost.

The body is more easily held erect in walking with the diverging steps.

The Indian in his long journeys seemed to prefer carrying his feet parallel, while the white man turns his toes outward, as a rule. If one

practices until he can walk well either way, an alternation of the two methods will be found to be restful when taking long walks.

31. By what means is the body protected from jars in walking? Which of the above-described modes of walking gives the more elastic step?

32. With the shoe removed, notice how the foot spreads gradually as the weight of the body is thrown forward upon it; what part of the foot should touch the ground first in order to reduce the jar most?

33. Why do tight shoes make the step inelastic?

34. Why do high-heeled shoes render it difficult to walk with the natural step?

35. What is the chief use of the arms in man? To what is their difference in function, from that of the fore limbs in most animals, due?

36. Compare their movements with the wings of a bird, the fore legs of the horse, dog, cat, and squirrel.

37. What general modification in form and attitude of the trunk accompanies the increasing freedom of movement in the fore limbs?

38. In what movements is the hand superior to the corresponding part in other animals? Note the position of the thumb and fingers.

39. What change in the position and attachment of the arms is associated with their great mobility?

40. What substitutes for legs do such animals as worms and snakes have?

41. Study the movements of a fish in the aquarium; what is the chief organ of locomotion?

42. What seems to have determined the shape of the body?

43. How does it turn itself? How does it rise and sink?

44. Does it require any effort on the part of the fish to remain in the usual position? Observe the position in which a dead fish floats.

45. By what means is it kept in an upright position?

46. Since the flight of a bird through the air and the swimming of a fish in the water are somewhat analogous, why is it that the modes of propulsion in the two cases are so very different?

NOTE.—Additional topics will be given under this head in the spring.

II. THE SKELETON.

It is desirable in this study to have some prepared skeletons ready for class use. A human skeleton should be procured if possible, both on account of its size and of the practical interest it possesses for pupils. Skeletons may be prepared quite easily from any small animal.

After killing the animal with chloroform or ether, such as a frog, mouse, or bird, cut all the meat away that comes off without danger of breaking a bone or separating a joint, and remove the contents of the body cavities. Then make a caustic potash solution, one ounce to a pint of water, and soak the carcass in this, at short intervals, removing the flesh as fast as it softens. To remove the brain, separate the skull from the spinal column, and use a crooked wire. With care in preparing the solution so that it will not be too strong, the flesh may be cleaned off before the ligaments soften enough to allow the bones to separate at the joints, and one may in this way secure an articulated skeleton. If the bones become separated, however, they may be mounted diagrammatically by sewing them to stiff card board.

1. Name several animals that you are sure have bony skeletons.
2. Name some that do not have skeletons.
3. Name some that have the skeletons on the outside of the body.
4. Of what use is our skeleton to us?
5. Of what use are the bones of our limbs? Of what additional use are the bones of the skull?
6. What uses can you discover for the ribs? Notice carefully the act of breathing.
7. Note in the prepared skeletons the two parts, the trunk, including head and neck, and the limbs, upper and lower.
8. Can you find such divisions in the skeleton of a frog? In the bird? The mouse? The squirrel?
9. Which, on the whole, most closely resembles our own?
10. In what respects are they all alike?
11. Which is most unlike our own? Which animal most closely resembles us in action?
12. Examine the skull of each. Wherein do they differ most?
13. Which contains relatively the largest cavity?
14. Which animal shows the greatest amount of intelligence?
15. Which the least?
16. Note the bones composing the skull. Look for the notched lines where they are joined. These are called sutures.
17. Do the bones move one upon the other?
18. Do they form a complete box? Are any of the skulls incomplete in this respect?

The large opening at the base of the human skull, the foramen magnum, is the passage for the spinal cord; the smaller openings, front and back, are for the passage of nerves and blood vessels.

19. How can you account for the difference in the shape of the heads of these animals?

20. What gives this difference of aspect, chiefly, the bones of the face, or those of the skull?

21. In what respects are the trunks all alike? Which are most alike? Between which are the greatest differences?

22. Which of the animals are most alike in their resting attitude?

23. Which are most alike when in action?

24. Can you tell whether it is the movements that determine the general form of an animal, or the shape that determines the general movements?

25. Can you see how the movements of the animals have determined any of the features noticed in the trunk?

26. Which has done more to give shape to the trunk as a whole, the position of the body while in motion or while at rest? Are all the animals alike in this respect?

27. In which animal is the trunk the most flexible?

28. How is the trunk rendered flexible? In what part is it most rigid? Why?

29. What are the advantages we derive from the flexibility of the trunk? Between the vertebræ are elastic pads of cartilage. Each pad is fastened to the vertebra above and the one immediately below it. The elasticity of the pads and their attachments permits of flexibility without the gliding of one bone over another, as in most joints, which in this case would endanger the delicate spinal cord within. These pads, with the curves of the spinal column, are usually thought to be largely instrumental in protecting the brain from jars and shocks incident to walking, jumping and similar movements. That this is not so to any great extent is evident to every one who has unexpectedly stepped into a hole a few inches deep. When knowingly taking such a step, the leg is so held as to remove the jar by bending slightly at the joints; otherwise, the position does not admit of this bending, and the shock is conveyed to the base of the spinal column and thence to the brain, and, even in a trivial misstep, it is one that is very generally dreaded.

30. In which animal are the fore and hind limbs most alike? In which most different?

31. Which animal uses its four limbs most nearly as we do?

32. In which animal is there the greatest difference between the fore and hind limbs? In which is there the greatest similarity?

33. In which animal is there the greatest difference in the use of the fore and hind limbs? Note the relative length of the fore and hind limbs.

34. Count the bones in the fore limb or arm of man, and compare with the other skeletons.

35. In which skeleton do the bones admit of the most varied movement? Which the least?

36. What is the chief use of the fore limb that has the greatest range of movement?

37. Note the relative length of the bones in the upper and lower arm in each animal.

38. In which animal are they relatively strongest? Note the relative length in each case.

39. Can you find bones in the fore limbs of the other animals to correspond with all those in the arm of man?

40. Which is most like man's arm in use?

41. How are the upper limbs fastened to the trunk in each case? Are they all alike in this respect?

42. What cause can you see for the difference, in this particular, between the mouse and bird? Between man and the mouse?

43. In which animal are the hind limbs relatively strongest? How do they compare with the fore limbs as to the number of the bones?

44. Note their attachment to the trunk; how do they differ in this from the fore limbs?

45. How have the bodily movements affected the hind limbs in each case?

46. How do the movements of the bones in the hind limbs differ from those of the corresponding bones in the fore limbs? Note the relative length of the bones of the hind limb, and compare with the fore limb.

47. How has the attitude of the body modified the hind limbs in each case?

48. How are they adapted to the movements of the animal?

49. In which skeleton is the foot most unlike the hand? In which is the greatest resemblance?

50. In which are the movements and uses of the foot and hand most nearly alike? In which most unlike?

52. Locate in four-footed creatures like the horse, dog, cat, etc., these joints found in man: toe joints, heel joints, knee joint, hip joint, wrist joint, finger joints, elbow joint and shoulder joint.

Botany.

A few observations should be kept up this month on the effects of frost and freezing on plants.

1. Sometime during a hard freeze examine the smaller twigs. Are they frozen through? How protected?
2. Open the buds; are they frozen? What are the ways by which the buds are protected?
3. Are they wet through when it rains?
4. Can you still distinguish the newly formed wood?
5. Is any part of the twig still green?
6. Look for seeds of weeds and other plants that have been scattered about; do they freeze?
7. Can you tell whether or not it kills them?
8. Are those that are buried in a few inches of earth frozen?
9. Look for acorns and other nuts; how does the freezing affect them?
10. Can you find any plants whose stems have been killed, but whose roots are still living?
11. Do the roots of the trees freeze?
12. Can you find any injurious effects of frost and freezing on the trunks of trees?

Physics.

I. THE LEVER.

It is the intention that the lessons given upon the lever should supplement those given in Zoölogy this month on the movements of animals. The pupils must provide themselves with small sticks about a foot long, and a block of wood, stone or iron an inch or two in diameter.

1. Suppose the block were a weight that could not be conveniently lifted by hand, illustrate with the stick the different ways in which a bar might be used in lifting it.

2. The pupil should work with this problem until he finds the three ways of using the stick as a lever. He should see that in each case there is a fixed point about which the lever moves which is called the fulcrum. Also that in each there is a point where the power is applied and another point where the weight is placed. He should note that the form of the lever depends upon the relative position of these three points, which are usually represented by the letters F , W , P . The distance from F to P is the power arm, and from F to W the weight arm of the lever. The three kinds are distinguished as first-class, when F is between P and W , second-class, when W is between F and P , and third-class, when P is between F and W . It will be noticed that one need remember only the point which lies between the ends in order to tell the class of lever, and in the order of first, second and third, the letters stand $F W P$, initials which no pupil of Cook County Normal School will find it difficult to remember.

3. How must the lever of the first class be used to lift the greatest weight? What do you notice about the relative length of the two arms $P F$ and $W F$?

4. Use it again so that it will be of the least use in lifting a weight; is there any advantage in such use? Note again the relative length of the two arms.

5. In the same way, use the second and third class forms of the lever. Note each time the relative length of the two arms, and also as to

whether the advantage gained in each case is one of *power* in lifting the weight or of *distance* through which it is moved.

6. Can the lever be so used that there will be no gain of either power or distance?

7. Is it possible to gain power with each form of lever?

8. What do you notice about the relative distance through which the power and weight move in the second class lever? Notice the same in the third class.

9. What determines the distance through which the power or weight shall move?

10. What forms of the lever have you seen workmen use? When do they use the first class? When the second class? When the third class?

11. Study some of the parts of the animal body as levers. What are their uses?

12. In studying the levers of the body, the pupil should first be required to fix the limits or ends of the lever, then the fixed point or fulcrum, then the weight and power. If this order be followed carefully, one step at a time, it is not difficult to fix the levers of the body and to tell the different orders.

13. In the manner suggested, locate and describe the levers concerned in the following movements: (1) Flexing the forearm; (2) extending forearm; (3) lifting the entire arm outward and upward from the body; (4) opening the mouth; (5) closing the mouth; (6) neck rigid, tipping head backwards and forwards; (7) throwing the head from one shoulder to the other; (8) straightening up when the body is bent at the hips; (9) lifting the body to tip-toe position; (10) standing on the heels and lifting the toes; (11) hold the foot clear of the floor and tap the it with the toes; (12) in same position lift the toes; (13) flexing the lower part of the leg; (14) in swinging the leg at the hip joint; (15) in the rib movement in breathing.

14. What class is most commonly found in the animal movements?

15. What advantages are derived in most cases from the form employed?

16. What disadvantages in the lever of the forearm?

17. In what position can you get the most strength or lifting power in the forearm? Test this by straightening the arm out on a table and then slowly flexing it against the upper arm.

18. Can you find similar levers used in the movements of other animals?

19. Why is it so difficult to hold an animal by its hind legs? Note the leverage and the class of lever in the fore-footed animals in the leg below the knee.

20. What kind of a lever is there in the wing of a bird?

21. How do animals move that are not provided with bones for levers?

II. HEAT.

A study of the following topics in this subject, should be applied in the explanation of whatever natural phenomena the pupils may have observed, which rest upon the principles here illustrated as a cause. Among the points which may be mentioned, are the cooling of surfaces upon which dew is formed, the origin and direction of air currents, modes of ventilation, effects of different kinds and colors of clothing upon the heat of the body, and so on. Careful consideration of the differences in bodies as to their capacity for heat will assist to a clearer comprehension of the relation of land and water masses to climate.

A. *Radiation, Absorption and Reflection.*

1. Heat an iron rod or bar in a flame till red hot, remove, and hold the face or hand near it on different sides. What is noticed as to the direction in which heat passes off? Heat thrown from a body thus is said to be *radiated*.

2. What becomes of the heat radiated from a body? Is it destroyed?

3. Does the rod radiate all its heat? When will radiation cease?

4. By what contrivances are rooms heated by radiation?

5. Why does the earth become cooler after sunset?

6. Which becomes cold faster, the land or the water?

7. Why is it that dew forms at nightfall?

8. Why is the formation of dew dependent upon the clearness of the night? Consult your Meteorological Record for the facts upon which to base your answer.

9. Compare and contrast with (8) the conditions under which fog forms.

10. When any body is held near a warmer one, how is the former affected by the latter? Anything so warmed is said to get its heat by *absorption*.

11. Is the absorption of heat affected by the smoothness or roughness of the surface of the body?

12. Does color affect the result? When opportunity offers, spread two small squares of cloth, one white and the other black, upon snow in the sunshine; after a time notice the rate of melting underneath each one. Try different materials of each color; is the rate of melting dependent upon the color or material and texture of the cloth?

13. Heat which strikes a body and is again thrown off is said to be *reflected*.

14. Are good radiators also good reflectors?

15. Are good radiators good absorbers?

B. *Conduction of Heat.*

1. In heating the metallic rods in (1) at one point, what did you notice as to the effect upon the entire rod?

2. Did the parts farthest from the flame become heated by radiation?

3. What parts became heated first? What parts last?

4. How does the heat get from one end of the rod to the other?

5. Procure pieces of different kinds of wire or rods, such as copper, iron and brass, one foot long. Twist them together in pairs for two inches at one end and from the point where they are twisted spread them apart in something of a U shape. At some distance from the twist, and at equal distances from each other, fasten by means of shoemaker's wax small bullets or shot to each wire. Support horizontally so that the twisted ends may rest in the flame of the lamp. Protect the balls from the *radiant* heat from the lamp with a screen.

6. From which wire do the balls drop first? What does that indicate?

7. Which is the last in losing the balls?

8. Bodies which become heated from particle to particle as in the case of the wires are called *conductors*.

9. What difference between heating by radiation and conduction?

10. Which is the better conductor, iron or copper? Brass or copper? Iron or brass?

11. Why does a piece of iron become heated when held in the hand? Why does it at first feel cold?

12. Why does wood feel less cold than iron to the touch? Why are iron handles sometimes tipped with wood?

13. Is the iron really colder than the wood?

14. Why does our bed feel cold at first? How does it become warmed?

15. Why does a blanket seem warmer than a sheet?
16. Why is linen clothing worn in summer and woollens in winter?
17. Why is it regarded safer for one's health to wear light woollens next the body, even in summer?

C. *Convection.*

1. Fill a good sized test-tube, or better still a glass beaker, nearly full of water. Sprinkle into it a little powdered chalk and heat gradually.
2. Look closely for any currents that may be started as indicated by the particles of chalk.
3. Make a drawing of the beaker, and mark with arrows the direction of the currents.
4. Where does the water become heated first? How do the other portions become heated?
5. Using light pieces of paper, look for currents of air in the room. Try the space over the stove or register; also the cracks above the doors and at the bottom. Open a window at top and bottom half an inch. Use a lighted candle or taper in looking for a draught.
6. What is the cause of the air movements in the room?
7. Can you account for their direction? Using a thermometer, find out where the lowest temperature is in the room, and whether it is at the top or bottom.
8. Recall the experiment illustrating expansion of air, which was performed in November.
9. How are those parts of the room distant from the stove or register heated?
10. Compare the heating of the air in the room with the heating of the water in the beaker.
11. The manner in which the water in the beaker and the air in the room are heated is known as *convection*.
12. How does convection differ from conduction?
13. Fill a test-tube nearly full of water, and *very cautiously* heat it near the top in the flame of the lamp; test at intervals with a thermometer the top and bottom portions. A small piece of ice held at the bottom of the water by a fragment of lead or a pebble will make the contrast stronger. Great care must be exercised in heating the test-tube in the last experiment, or it will crack; why is this?
14. Does the water become heated throughout more or less quickly than before?

15. What makes the difference? By what process is it heated in the latter case?
16. Why is it not heated by convection?
17. Study the mechanism of the kitchen range, and explain how the water in the boiler is heated.
18. When the fire is starting, which part of the boiler gets warm first? Place the hands at different points on the outside.
19. How does the water in the lake become heated? Explain why it is always cold a little distance below the surface.
20. How does the sun warm the earth?
21. Is the air warmed directly by the sun?
22. Can you see any reason why it is colder on a mountain peak than it is on a low plain?
23. Hold a piece of plain glass between the hand and the sun; can you notice any change in the amount of heat that reaches the hand?
24. Instead of the plain glass, use a common magnifying glass or lens; hold it so that the sunlight passing through it is reduced to a small point. Allow this to fall upon the hand or upon paper. How can you account for the great heat at that point? Is it hot outside the area of this spot? Try to make a drawing, showing by lines the way the heat must come to the lens and the way it must leave it on the opposite side. Heat bent out of a straight course by some substance which it passes through is said to be *refracted*. Compare reflection with refraction.

D. Capacity for Heat.

1. In two vessels of the same kind, place equal amounts of water; raise the water in one of the vessels to the boiling point and take the temperature. Find the temperature of the water in the other vessel, and then add the boiling water to it.
2. What is the temperature of the mixture? How much was the cool water warmed? How much was the warm water cooled? Is the number of degrees the same in both cases? Is the result what you would expect from the experiment?
3. Take a piece of lead weighing three or four ounces. If not already in a sheet, pound it out thin and roll loosely. Suspend in a vessel of boiling water and allow it to remain until it has the same temperature as the water. Into another vessel put a weight of water equal to that of the lead, and take its temperature. As quickly as possible drop the lead into this vessel of water and take the tempera-

ture. How much does the temperature of the water rise? How much does that of the lead fall?

4. In the same way use different substances, as zinc, sheet iron, tin, brass, and copper.

5. Notice how much the water gains in each case and how much the metal loses.

6. How much heat must have been in the metal when taken from the boiling water? What became of this when it was dropped into the cooler water?

7. Does the thermometer always tell us when heat is added to a substance? Recall the experiment of the melting ice in the November work.

E. Sources of Heat.

1. How do we warm our houses? What are necessary in order that we may have a fire?

2. When the wood or coal burns, what kind of a change takes place? (See Chemistry for November.)

3. Have you ever known heat to be produced without the use of fire?

4. Try rubbing a nail with a file. Rub two sticks together. Rub the edge of a penny over the sleeve. What results in each case?

5. Pound a nail on a stone or iron block with a hammer; what is the result?

6. What is the real difference between the two ways of getting heat, that of burning the wood, and that of making it warm by rubbing it?

Chemistry.

PREPARATION OF OXYGEN.

A. *Materials needed.*

1. Test tubes, one for each pupil if possible, about six inches long and three-quarters of an inch in diameter.
2. A six-ounce Florence flask.
3. Corks to fit the above.
4. Glass tubing having a bore of about three-sixteenths of an inch. A piece about eight inches long for each pupil. Bend the tubes at a right angle two inches from one end, and put the short end through a hole in the cork.
5. Glass bottles with wide mouths, at least one for each pupil, and a few empty glass fruit jars.
6. A pneumatic trough. Any vessel holding five or six inches of water will answer. A small bench with a hole in the centre must be used for supporting inverted vessels in the water with their mouths below the surface. To make this take a strip of tin about eight inches long, four inches wide, and bend up two inches at each end. This will be strong enough to support small jars and bottles.
7. Alcohol lamps or Bunsen burners.
8. About an ounce of potassium chlorate and an equal amount of black oxide of manganese for each pupil. Test these materials by powdering a little of the potassium chlorate and mixing with the same amount of the black oxide and heating in an open tube: if the mixture melts quietly they are safe; if slight explosions occur, throw the materials away, as they are not pure and are dangerous.

B. *Experiments.*

Mix the powdered crystals of the chlorate with an equal amount of the black oxide; put about one inch depth of this into a test tube and fix with a cork having a tube through it as described above. Fill one or more small bottles with water and invert in the pneumatic trough, which should have four or five inches of water in it. Place one of

these upon the bench with the mouth over the hole. Support the test tube over the flame so that the end of the glass tube will be under the surface of the water in the trough, but *not under the bottle on the bench*. After the bubbles have escaped for a few moments, arrange the end of the tube under the hole in the bench so that they will rise into the bottle.

2. Why not put the end of the tube under the bottles at once?
3. Why fill the bottle first with water?
4. Can you see anything passing out through the tube?
5. What change do you notice in the materials in the tube?
6. What is the nature of the substance rising into the bottle of water?

7. When the water has left the bottle, remove it from the hole, but keep the mouth below the surface. If gas still comes off, replace it with another bottle.

8. Slip a piece of glass as a cover under the bottle filled with gas, and holding it tightly in place, remove the bottle and turn it quickly right side up.

9. Provide a number of fine splinters. Light one of them, and, when fairly blazing, blow it out and quickly thrust the glowing end into a jar or bottle that contains air; note carefully all that happens.

10. Light again, and in the same manner thrust it into the jar filled with gas from the test tube; what difference do you notice?

11. What evidence that there is something in the jar different from air?

12. With a fresh supply of gas, repeat the experiment suggested above in (9), using a short piece of a candle. Fasten a light piece of wire around the candle by which it may be lowered into the jar.

13. After the pupils have made oxygen for themselves, it may be desirable to have a larger quantity and have it collected in the fruit jars. To do this take about an ounce of the potassium chlorate and mix with the manganese as before, and use the Florence flask. Heat gradually, and when enough has been collected remove the end of the tube from the water before removing the flame. If this precaution is not observed, the water will run back into the flask and break it.

14. Put a small amount of sulphur in a thimble and ignite it; by means of a wire wrapped around it for a handle, lower it into a jar of the gas.

15. Ignite a piece of well-charred charcoal and lower into a fresh jar of gas.

16. Fasten a small splinter to an iron wire, and after lighting lower it into a jar of the gas.

17. Get a worn-out watch spring from the jeweler's and draw the temper by heating, and then straighten it; fasten to a stick as in (16) and after igniting lower it into a jar of the gas.

18. In the same way try a narrow ribbon of zinc.

19. In the foregoing experiments does the gas in the jars burn?

20. In what respects is it like air?

21. What happens after burning a substance, as wood, in the jar for some time? Compare this result with what was observed when burning a taper in a bottle of air.

22. The gas collected in the jars used in these experiments is called *Oxygen*. It is the element in the air which enables us to have fires in our stoves and grates.

23. It is also the life-giving element of the air for animals. How does it enter our bodies?

24. Why should chimneys have a good draught to make good fires?

25. Why do we fan or blow a fire to start it?

26. Why do we need ventilation in a room?

27. In what respects does oxygen differ from the carbon dioxide gas? (See Chemistry for November.)

Meteorology.

1. Has the prevailing wind changed direction within the last three months? What may be given as causes?
2. Has the cloudiness increased or diminished?
3. How does the character of the rains differ from those in September? What causes the difference?
4. From what direction do the heaviest rains come?
5. In what month has the greatest number of fogs been noted?
6. What conditions are most favorable for the production of fogs?
7. Is the wind more or less variable than it has been in the preceding months?
8. What wind precedes the heaviest rains?
9. What wind accompanies clearing weather?
20. Is the temperature increasing or diminishing this month? What cause can be given? (See Astronomy for December.)
11. Is the rate of change in temperature more or less rapid than it was in the preceding three months?
12. When have most of the rains occurred, in the daytime or during the night?
13. Of those rains which occurred in daytime, did the greater number fall in the forenoon or afternoon?
14. Have the frosty mornings been followed by fair or foul weather?
15. On what date did the first snow fall?
16. From what direction do the snows come?
17. Do rains come from the same direction?
18. Examine some single snow-flakes closely; are they all alike?
19. Are they all of regular form? Why are some flakes larger than others?
20. How do snow clouds differ in appearance from rain clouds?
21. How does the history of a snow-flake resemble that of a rain-drop? In what respect is it different?
22. Does the barometer in any way herald the approach of a snow storm?

23. At what temperature did the heaviest snow fall? Did the temperature rise or fall after the snowing ceased?

STUDIES OF SIGNAL SERVICE MAPS.

24. Draw a line across the map connecting the points furthest south where snow has fallen during the last month. This may be called the snow line for the month.

25. Where does the snow line extend farthest south?

26. Where is its most northern point?

27. How many degrees of latitude are they apart? How many miles are they apart north and south?

28. How do the coast lines affect the snow line?

29. On which coast is it farthest north? Why is it so?

30. Which mountains have the most marked effect upon it, the Rocky Mountains or Appalachian system?

31. How does the course of the storms for this month compare with that for the preceding months?

32. Have the courses of the great rivers affected apparently the direction of the storms?

33. Have the mountains determined the course of the storms?

34. Have there been any great storms with rain in one part of its area and snow in another part?

35. Contrast the Pacific slope with the Atlantic as to rain-fall and temperature this month.

Astronomy.

1. Compare the relative length of day and night in December with that of preceding months.

2. What has been the average rate of change in the length of day during the month? Compare with the former months.

3. Note the position of the noon shadow about the 21st of the month. Has it changed its position more or less rapidly this month than it did in September?

4. Stretch a string from the top of the upright piece at the end to the point touched by the noon shadow on September 22d, and another string to the point touched by the shadow December 21. Note the size of the angle between the two lines. If possible, measure it. If these two lines were continued into space, what two points in the celestial sphere would be found?

5. Note as directed in September the points on the horizon where the sun rises and sets.

6. How have these positions changed since September?

7. What suppositions can you make regarding the earth and sun which will account for the changes?

8. Suppose you were to draw lines across the sky marking the apparent path of the sun every day since September, what would be the relation of these lines to each other?

9. How much of the quarter circle on the horizon has the sun traversed since the 22d of September?

10. Compare the number of degrees estimated in (9) with the size of the angle measured in (4).

11. Can you show, by means of the globe, on the supposition of revolution, what part of the earth's orbit has been traversed since the autumnal equinox?

12. How many days have elapsed since then?

13. Does the fraction of a year which has passed since the equinox correspond to the part of the orbit over which the earth has passed since then?

14. What supposition can you make that will explain the lack of correspondence?

15. Explain, by means of a globe, why the sun has seemed to change its position since September.

16. Write a brief description of the condition of animal and plant life. Compare with September. To what cause or causes are the differences due?

17. Do you always see the same side of the moon? By means of a globe, sun and moon, explain.

18. Can you see any reason for believing that the moon revolves round the earth?

19. If the moon revolves round the earth as the earth moves through its orbit round the sun, can you tell what kind of a line it must describe?

20. Have any of the constellations which were seen last month disappeared?

In addition to those of last month that are still visible are Auriga, Orion and Gemini.

Geography.

I. NORTH AMERICA.

Soil and Productions.

1. What things can you name that affect the fertility and productiveness of soils?
2. Make use of a good physical relief map and study the conditions which affect the productiveness of the different regions. From what you know of plant life, what are the primary conditions necessary for it?
3. Contrast the growth and general appearance of a plant during a wet season, with its condition during a dry one?
4. What is the effect of heat and moisture upon the plants that you have noticed?
5. Use a map which shows the character of the vegetation in different regions; what climate have those parts where vegetation is most luxuriant.
6. What contrasts in the products of the Atlantic and the Pacific coast regions?
7. Compare the northern half with the southern on each coast; on which coast is the contrast greater?
8. In the great central plain, contrast the eastern and the western halves; in which half within the United States are the productions more uniform?
9. In which half do the agricultural productions extend farther north?
10. Where are the great wheat growing regions? How can you account for the wheat growing region of Texas, since a similar one is not to be found in Mississippi?
11. Where is the rice production greatest? Contrast the conditions that it requires with those necessary for wheat?
12. Note the cotton-growing region; does the belt reach the Rocky Mountains? Can you see a reason for this?

13. Contrast the corn producing regions with those mostly devoted to wheat?
14. What is the relation of the tobacco and hemp regions to those of cotton and corn?
15. What grains flourish in a cooler climate than that best adapted for wheat?
16. Make a study of the different fruit regions; what part of the continent includes the greater part of the fruit-growing regions?
17. Compare and contrast the Atlantic and the Pacific coasts. What are the staples of each?
18. Where is the southern boundary of the apple region? Where is the chief apple-growing district?
19. What effect, if any, do the Great Lakes have upon the surrounding country in the production of fruit?
20. What climate seems best suited to peach-raising?
21. What is best adapted for oranges?
22. What fruits are produced south of the United States? What ones are produced north of the United States?
23. Where do the fruits grow farthest north, along the coasts or in the interior?

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Minerals.

24. From what parts of the continent are the minerals chiefly obtained?
25. Contrast the eastern and western highlands as to the variety and kinds of minerals produced.
26. Locate the iron mines that are now being worked most extensively. Where are the copper mines?
27. Where are the bituminous coal regions? The anthracite coal fields?
28. Where are the gold and silver mines? The mines of quick-silver? Of lead?
29. Where are the petroleum deposits?
30. What cities are the chief agricultural depots in the north? In the south?
31. What are the chief mining cities? What is the chief coke manufacturing city in the country?

II. SOUTH AMERICA. CLIMATE.

1. Use a good physical map, upon which the ocean currents and

winds are clearly marked. Model the map to get an idea of the climatic effect of the highlands, river basins and coast lines.

2. How does the latitude of South America affect its climate? Contrast it in this respect with North America.

3. Contrast the area of South America that lies within the tropics with that of North America in the corresponding latitude; what climatic differences must be due to these contrasts?

4. In the same way compare the temperate regions of the two continents.

5. What climatic difference must be due to the difference in the character of the coast lines of the two continents?

6. What modification of the climate in the tropical regions must be due to the differences in relief?

7. How does the position of the great Andean highland affect the climate within the tropics?

8. What is the direction of the prevailing wind within the tropics? What must be its character as to moisture?

9. What agencies for condensing the moisture in the northern half of the continent?

10. Contrast the western slope of the Andes within the tropics with the eastern; to what are the differences due?

11. What do the rivers indicate as to the amount of moisture east of the Andes?

12. What ocean current sweeps the eastern shores in the temperate regions? Does it set towards or away from the coast? What is the direction of the wind?

13. What ocean current skirts the western coast? What wind west of the mountains?

14. Contrast the southern half of the Pacific coast with the northern; what causes the differences?

15. Contrast and account for the differences noted between the eastern and the western coasts of the southern half of the continent.

16. Latitude 50° north or south is noted as embracing regions where fogs are prevalent; can you account for this?

Geology.

During the winter season, opportunity should be taken to study atmospheric and aqueous agencies that are constantly but slowly changing the face of the earth by means of frost and ice. The action of these may be seen and studied on a large scale, if one has a chance to visit a cliff, a river shore, a pond or lake beach, and quarries. One or more of these can hardly fail to be convenient in almost every neighborhood, and, of course, whatever is present should receive the larger share of attention. In lieu of a cliff, however, a stone wall will sometimes make a good substitute; or, what is generally better, the bank of some ditch will show how the water, soaking down and then freezing, loosens masses of earth which fall off and form a *talus* at the bottom. A small stream, a roadside brook it may be, will often show exactly how a river's banks are clutched by the icy fingers which sooner or later carry away masses of earth, rock and drift and deposit it elsewhere. The ice which forms under a cliff, as will be illustrated by that formed along any steep bank, receives considerable material dropped from above, which it bears away when thawed loose from the shore. Sometimes in beds of finest clay, large boulders are to be found that cannot well be accounted for, except on the supposition that they were dropped by floating ice, which doubtless bore them to the spot from some distant place. When the ice breaks up after a rain, its work in gouging and cutting the banks as it is carried along by the current may be observed. The formation of ice dams or gorges, and their subsequent bursting with the effects of the flood which follows, may also be noticed in any stream, at almost any sharp curve, or where some obstruction chokes the channel.

The freezing and thawing of the ground is also an interesting subject for observation and study. The freezing of the soil uplifts and loosens it, so that erosion takes place more easily. By the uplifting and consequent settling movements, the roots of grasses and other plants are sometimes left exposed, and are then killed. On hillsides, the effects are still more marked. Water falling in hollows above

stumps, trees and rocks, by its alternate freezing and thawing tends to push such objects a little farther down the slope. This will be noticed in the spring after a thaw, when trees will frequently be found uprooted, and rocks will be moved a little from their winter bed.

In quarries, or where rocks have been long exposed to the weather, by means of cracks or seams of softer material which has been washed out, water finds access to a greater or less depth below the surface. When frozen it operates with great force in splitting the rocks apart.

1. Examine the ground in various places and find out something as to the depth it is frozen. Study the influences which cause variation in the depth.

2. Compare places near a building and on the different sides; on which side is it frozen deepest?

3. Find a place where the ground is composed of clay; compare the depth to which it freezes with a place composed of sand. Compare both with vegetable mould and loam. What precautions must you observe in the selection of places of observation, that your results may be trustworthy?

4. How can you account for the different depths frozen in the various places?

5. Compare a piece of ground covered with heavy sod with one without vegetation; which is frozen deeper?

6. What difference in the freezing of the ground under a large flat stone and that around it uncovered? In the same way examine the earth under a board, and compare with that under a thin stone.

7. Compare wet with dry places; which freeze deeper, and the sooner?

8. What effect does a forest have upon the freezing of the ground?

9. Compare places covered with snow with others where the snow is blown away; how do you account for the different depths to which the ground is frozen?

10. Does vegetation increase or diminish the possibilities of the soil for taking up water?

11. Does the depth to which ground freezes seem to depend upon the water it soaks up?

12. If there is opportunity, examine a freshly flowed field and compare it with one that has settled compactly.

13. Can you see any signs of weathering away of the stones in the walls in different buildings?

14. Secure specimens of the different kinds of stone, and study the closeness of the grain in each.
15. Can you see a cause for their wearing away? Are there any cracks or seams?
16. Does a stone freeze through like a lump of earth?
17. When broken, can you find any frost crystals below the surface?
18. Do stones take up water like the soil? To test this, dry specimens of these taken from walls and elsewhere, and weigh them; then soak in water for awhile, dry with a cloth as much as possible, and weigh again.
19. Which ones gained most weight? How do they rank as to durability in walls, etc?
20. Test in the same way pieces of mortar or cement from walls or pavements, and also pieces of brick.
21. Compare in this manner different kinds of stones, such as limestone, marble, flint, granite, sandstone and slate; does their durability correspond in any way to their absorptive powers?

Mineralogy.

If the pupils, during the preceding months, have been reasonably industrious in making their collections, they will, no doubt, have found, among the rest, one or more varieties of iron ore. Good examples of this valuable ore may usually be picked up along railroads where it has been dropped from passing trains laden with it. If there are smelting furnaces near, it may be easily obtained in quantity, and, usually, in great variety. If possible, also, secure good specimens of pig-iron, slag, rolled bar, cast-iron and steel. With younger pupils a collection of tools, utensils, instruments, etc., would be valuable in illustrating the properties of each. Sample sets of these may often be procured from manufacturers, who are almost always willing to furnish them to any school that will give suitable space for the exhibit. Much of the wall space, between the blackboard and ceiling, too often bare and unsightly, may well be given up to this purpose. Such displays, by no means necessarily confined to this one subject, will often be used directly, as means of illustration in teaching, and indirectly, by their constant presence, they will, in many pupils, stimulate thought and impress the mind with some notion of the useful industries.

The richest ores from which iron is obtained are Magnetite, Hematite and Limonite, classed as oxides, and Siderite and Clay Ironstone, among the carbonates. For specific descriptions of these, the teacher is referred to "Crosby's Tables for the Determination of Minerals," a copy of which every teacher should have, and to Dana's Manual of Mineralogy. The latter contains a brief description of the different kinds.

Pupils are generally anxious to know the names of the different minerals that they find, and it is proper that the teacher should give the names when convinced that the questions are based upon something higher than idle curiosity. As a rule, the teacher should give no help until sure that the pupil himself has invested some thought in the subject. To insure this, a blank form for the description should

be given the pupil, to be filled out from his own study of the mineral. When this has been done, the teacher may then give the name, and feel fairly assured that he is helping one who really wishes to know. Of course, these blanks cannot be completely filled until the preceding lessons upon the physical characteristics of minerals have been given and understood. But they may be used to advantage from the beginning, the pupil filling them out as the work proceeds. For simple methods of making the tests with acids and the flame, the teacher is referred to Crosby's Tables, or any manual of determinative mineralogy. The acid test is easily made, and will add interest from the start. The flame tests should not be attempted until the pupils are familiar with the more obvious characteristics.

Four blanks, such as the one appended below, may be prepared upon the sheet, $8\frac{1}{2} \times 11$ inches, which was recommended on a preceding page as a convenient size for Science work. These sheets, when filled, may be filed away with the rest of the pupil's written work, and constitute a part of his year's record.

DESCRIPTION OF MINERAL.	
By _____	No. _____.
1. Hardness	Grade _____.
2. Lustre	Date _____.
3. Streak	
4. Diaphaneity.	
5. Color.	
6. Taste, Odor	
7. Specific Gravity	
8. Form.	
9. With Acid.	
10. Flame	
11. Name.	

1. What strongly marked characteristic is common to all iron ores? 1

2. Find the specific gravity of the different varieties; what one is heaviest?

3. Powder a small piece of each kind and test with the magnet; which is most strongly magnetic? Are any not attracted at all?

4. What is the hardness of each?

5. What difference noticed in the streak?

6. Compare as to color; what color distinguishes the magnetite?

7. What difference in shade between limonite and hematite? If a specimen of specular iron ore, the purest variety of hematite, can be found, it will be recognized by its shining mica-like blades with a metallic lustre.

8. Siderite, iron carbonate, is another variety less rich in iron and varying much in its appearance.

9. Examine specimens of pig-iron, cast-iron, wrought-iron and steel. How do they differ in appearance? Can you find any evidence of crystals in any of the specimens?

10. What different properties do they possess?

11. Pig-iron is obtained directly from the ore by smelting it in a large furnace with an intense heat. The ore is mingled with broken limestone and coal. By means of a hot blast the iron is melted out and settles to the bottom, and the lighter impurities remain on the top. At intervals the melted iron is drawn off into a number of molds formed in sand, called pigs. This process gives the crude iron. The succeeding processes, puddling, hammering and rolling, are designed to rid it of its impurities and give it fibre and toughness.

Cast-iron articles are made by pouring the melted metal into moulds of the desired form.

12. How many uses can you name for cast iron?

13. What would seem to be its most useful property?

14. Compare it in appearance with cast steel?

15. What useful articles are made from steel? What are its valuable properties? A most useful characteristic of steel is that it may be so treated as to have different degrees of hardness and elasticity. Take a fine steel knitting-needle and bend it. On being released it regains its former shape by its elasticity. Heat to redness and plunge into cold water, and it will become hard and brittle and break easily. Heat again and allow it to cool slowly, and it becomes softer. The process of reheating and cooling of steel is called tempering, and by it many different degrees of hardness and elasticity are obtained.

16. What are the chief uses of rolled iron? How does a freshly broken surface differ in appearance from that of cast iron or steel?

17. What are its most useful properties?

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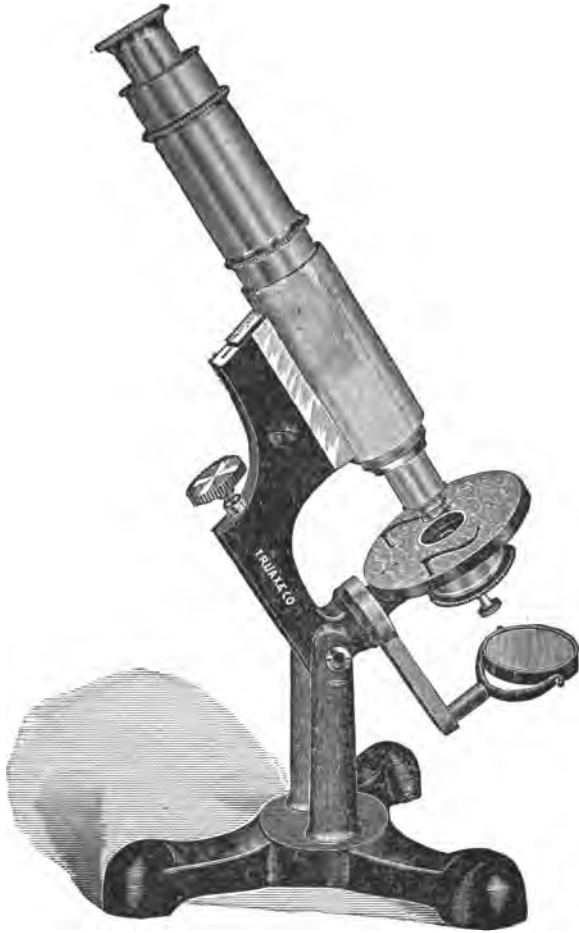
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